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(24)

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TECHNICAL REPORT 81-3

PERFORMANCE OF ASPHALT CONCRETE PAVEMENTS CONTAINING ANTI-STRIPPING ADDITIVES

December 1981

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bureau
technical
services
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NEW YORK STATE DEPARTMENT OF TRANSPORTATION

1220 WASHINGTON AVENUE, ALBANY, NY 12232

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PREFACE

This report reviews the use of heat stable anti-stripping additives in New York State. The additives were pre-blended with the asphalt cement and were used in Regions 1, 3, and 7 (Albany, Syracuse, and Watertown) for various periods of time between 1976 and 1981. Performance evaluations of pavements containing the additives and laboratory testing of samples from these pavements indicated that any long term performance benefits derived from the addition (of the additive) were negligible. Therefore, it was concluded that the addition was not cost effective.

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I. INTRODUCTION

Poor bituminous concrete pavement performance encountered on high traffic volume highways has been a major concern for a number of years. Early investigation of this problem revealed that one of the major causes of this poor performance was the action of water breaking the bond between the non-carbonate coarse aggregate particles and the asphalt cement (stripping).

In June 1976, the use of heat stable anti-stripping additives began in an attempt to reduce the occurrence of this stripping and improve pavement performance. At this time the Department's position concerning these additives was as follows:

1. Expand the Department's knowledge on the use and effectiveness of these additives.

2. Evaluate the performance of pavements containing the additive and compare the performance to pavements without the additive.

3. Require the use of additives in selected areas of the state.

The Materials Bureau adopted a stripping test method (Appendix 1) and tested various heat stable anti-stripping additives with different combinations of non-carbonate aggregates and asphalt cement to determine the effectiveness of each additive. Additives passing this stripping test were approved for use. Initially, the required dosage rate for all additives was 0.5% (based on the weight of asphalt cement), but this rate was modified as new additives became available. In addition, the asphalt cement treated with anti-stripping additive had to meet all specification requirements for untreated asphalt cements.

To insure complete dispersion of the additive into the asphalt cement, the Department required that the additive be in-line blended either at the asphalt cement terminal or at the mixing plant. The method of blending and the equipment had to meet the approval of the Regional Director or his representative. Since the additives have a shelf life which could limit their effectiveness, Department policy was established that if the treated asphalt cement was held four days or less it was acceptable. Treated asphalt cement held 4-7 days was conditionally acceptable based upon stripping test results done by the plant inspector. Treated asphalt cement held longer than 7 days was not acceptable and considered as untreated asphalt cement. Periodic testing of the treated asphalt cement was done by the plant inspector to confirm both the presence and effectiveness of the additives.

Heat stable anti-stripping additives were used in Region 3 (Syracuse), Region 1 (Albany) and Region 7 (Watertown) during the period 1976-1981. The purpose of this report is to document the performance of the additive in the pavement.

II. REGION EXPERIENCE

A. Region 3 (Syracuse)

1. Background -
Starting in July 1976, all Region 3 contracts contained a "Special Note" that required all asphalt concrete high friction top course mixes (excluding dolomite mixes) to use asphalt cement treated with an approved heat stable anti-stripping additive.

   The 1977 Region 3 O.G.S. Maintenance Bid Proposals for Bituminous Concrete were also changed to require the addition of approved anti-stripping additive to asphalt cements for high friction top course mixes.

2. Observation/Analysis -
In the Fall of 1980, 16 different projects were visually evaluated and sampled. Nine of these projects had top courses with anti-stripping additives and 7 without. Four of the projects without the additive were located in Region 7 and contained the same type high friction aggregate that was used in Region 3 top courses. One-hundred cores were taken from these projects and evaluated. In the summer of 1981, these pavements were reinspected. The results of the visual evaluation and the core test results are included in Appendix 2.

   Each core was broken up and the coarse aggregate was visually examined. No distinct difference was observed between those cores containing anti-stripping additive and those with none. Overall, the majority of coarse aggregate particles in all the cores appeared to be well coated except for one project where water was moving through the pavement. Although this particular project (Route I-81 near Cortland) had the anti-stripping additive in the mix, all the aggregate was stripped. The physical test properties of the cores and asphalt cement did not show any difference between those cores with additive and those without.

   The visual evaluation of the pavements showed that all pavements with the exception of one are performing satisfactorily. Contract D95619 Interstate 81 near Cortland showed distress in the form of isolated potholing and ravelling. Due to water in the overlay, the gravel coarse aggregate particles exhibited severe stripping which caused the ravelling. As mentioned previously, this overlay included the anti-stripping additive which did not prevent the aggregate from stripping after 3 years in service.

Other pavements, both with and without additives, contained stripped coarse aggregate particles but no ravelling or other distress that affected performance. No visual evidence indicating that the pavements containing the anti-stripping additive were out performing those without the additive was observed.

The use of the additive was discontinued in August 1981.

B. Region 1 (Albany)

1. Background -
In 1977, I-87 located in Region 1 was resurfaced between exits 24-26N using a crushed gravel. During the initial phase of this construction it was determined by the Region Materials personnel that this aggregate had stripping tendencies. An order-on-contract was initiated to require the use of anti-stripping additive with the binder and top courses. Two-thirds of the binder course and all the top course received the additive. In 1978, two other I-87 resurfacing contracts were completed using this same type crushed gravel and anti-stripping additive.

2. Observation/Analysis -
In 1978 when paving was being completed on the two I-87 contracts, it was noticed that there was some pavement surface distress in the contract completed in 1977. The surface course on some sections of the project had shoved under traffic and left humps in the wheel paths. These humps contained numerous pieces of aggregate that showed signs of asphalt stripping. Further investigation of the entire project indicated that much of the gravel aggregate in the surface course showed signs of stripping.

A number of asphalt cement samples with the anti-stripping additive were retained at the plant producing the mixes in 1977. All these samples had passed initial stripping tests. These retained samples were tested to determine the effectiveness of the additive after one year shelf storage. All samples failed the stripping test which indicated the admixture may have a shelf life and may not be effective in the pavement after some time period had elapsed.

In the Fall of 1978, a number of cores were taken from each of the three projects paved using the anti-stripping admixtures. Test results indicated the physical properties of the cores and recovered asphalt cements were well within the acceptable limits.

In December 1978 the Region postponed two I-87 projects scheduled for letting in 1979 until additional evaluations could be done. The Engineering Research and Development Bureau assisted the Materials Bureau in evaluating the stripping susceptibility of aggregates from two northern sources. These sources were potential candidates for use in the two upcoming contracts. The aggregates were evaluated using varying dosage rates of different anti-stripping admixtures. Stripping potential was evaluated on the basis of indirect tensile strength tests from which tensile strength ratios were determined after two different simulated exposure treatments. Tests concluded that only one admixture at 1.0 percent was effective in improving tensile strength ratios for both short and long term evaluations. However, there was visual evidence of stripping in the specimens. The study concluded that the dolomite aggregate, which was used as a control and passed all tests, be used instead of the gravel aggregates. The report "Stripping Susceptibility of Aggregates from two sources in Northern New York State" can be found in Appendix 3.

The use of the additive was discontinued in December 1978.

In July 1979 the Regional and Main Office Materials Bureau personnel examined several northern projects which had used gravel aggregates and been in service for a number of years. Visual evaluations indicated that some stripping of the aggregate was evident, but the traffic volume and loading of the roadways was such that no visible surface distress was apparent to reduce serviceability (Appendix 4).

C. Region 7 (Watertown)

1. Background -
In 1977, Region 7 decided that since many of their non-carbonate aggregate exhibited stripping susceptibility they should evaluate the use of anti-stripping additives. A special note requiring that the additive be added only to top and binder courses composed entirely of non-carbonate coarse aggregate was inserted in all proposals.

2. Observation/Analysis -
A number of cores were taken from Contract D95800, NYS Route 3 between Cranberry Lake and Sevey's Corners after one year service. The core results and visual evaluation indicated that no immediate benefits were derived from the use of the additive. The use of the additive was terminated in January 1980 based on the findings in Region 7 and Region 1.

III. RESULTS

Region 3 pavement core test results and pavement evaluations performed on pavements in-service for up to four years, showed no long term performance benefits from adding heat stable anti-stripping additives to high friction top course mixes. Results also indicated that dense graded top course mixes properly designed and constructed produce low permeable pavement surfaces with low air voids and high densities. This type of pavement reduces water entering the pavement and minimizes the chance for stripping.

After reviewing all the evaluations and test core results from Region 1, it was determined that any initial benefit derived from the addition of additive was negated after a short period of time. Pavement cores taken from sections with and without the additive showed the same degree of aggregate stripping after one year service. Stripping tests on asphalt cements containing the additive and stored for one year resulted in failing tests.

Region 7 evaluation and testing also indicated that no immediate benefits were derived from adding the additive. Pavement performance evaluations and the increased cost of approximately one dollar per ton have shown that the use of these additives is not cost effective.

IV. CONCLUSIONS

The conclusions of this study are as follows:

1. Any long term performance benefits derived from adding heat stable anti-stripping additive to asphalt concrete course mixes are negligible.

2. Any benefits derived from the initial addition of the additive are negated after a short period of time. The additive has a "shelf" life.

3. Benefits derived from the addition of the additive are not cost effective.

4. Dense graded asphalt concrete mixes properly designed and constructed result in relatively impervious surfaces. This type of surface reduces water from entering pavement, thus minimizing the chance for stripping.

5. One admixture at 1.0 percent (by weight of asphalt cement) was effective in improving tensile strength ratios of mixes for both short and long term evaluations. However there was visual evidence of stripping in the specimens.

APPENDIX A

STRIPPING TEST METHOD

TEST METHOD FOR DETERMINING STRIPPING TENDENCIES FOR COARSE AGGREGATES

SCOPE: This method covers the procedure for testing coarse aggregate particles used in asphalt paving mixtures for retention of a bituminous film in the presence of water and the procedure for determining the effectiveness of anti-stripping additives when added to asphalt cement.

APPARATUS:
a. Sieves, standard, square hole, of 1/2 in. and 1/4 in. size.
b. Scale - Capacity of 200 g., accurate to ±0.1 g.
c. Constant Temperature oven capable of maintaining a constant temperature of 300°F.
d. Containers, for mixing, having rounded sides, such as seamless tin cans, 12-16 oz. capacity.
e. Spatula for mixing the aggregate particles and asphalt cement.
f. Burner - open flame gas operated, or electric.

MATERIALS:
a. Treated asphalt cement - use the asphalt cement produced by the same manufacturer(s) and of the same grade(s) as that to be used in the project with the aggregate under test. Preheat asphalt cement and additive to 300°F. Thenmix in the manufacturers prescribed dosage of anti-stripping additive to the asphalt cement.
b. Aggregate - Test aggregate is to be of such a size that 100% passes a 1/2 in. sieve and is retained on a 1/4 in. sieve.
c. Distilled water

REFERENCE STANDARD:
a. An aggregate which is known to exhibit loss of asphalt coating after undergoing the test procedure as outlined here. (Wellesley Is. granite)
b. An aggregate which is known not to have stripping tendencies (limestone).

PROCEDURE:
1. Coating - Weigh 100 g. of the dry, washed aggregate at room temperature into the mixing container and heat in an oven to approximately 300°F. To the heated aggregate add 5.0 ±1 g. of the treated asphalt cement which has also been preheated to 300°F. Mix the asphalt cement and aggregate vigorously with the spatula until all the stone has a uniform coating, no bare spots are permissible.
2. Curing - Let the coated aggregate cool to ambient temperature.
3. Testing - Add enough distilled water to cover the coated stone in the container. Place the container over a source of direct heat (an open flame or an electric burner) and bring the water to a full, rolling boil for one minute. Remove the container from the burner and immediately rinse the contents with tap water.
4. Visual Examination. Compare against reference standard.

May 5, 1981

TEST METHOD FOR DETERMINING STRIPPING TENDENCIES FOR COARSE AGGREGATES

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4. Visual Examination. Compare against reference standard.

May 5, 1981

ANTI-STRIPPING ADDITIVE INVESTIGATION

CONTRACT NUMBER:	LOCATION:	MIX: PLACED:	PLANT:	HIGH FRICTION AGGREGATE:	ADDITIVE:
D95431	ROUTE 5; ONONDAGA COUNTY Elbridge - Camillus, Part 2 Camillus - Fairmount, Part 1 & Part 2	1-ACF 1977	Warren Brothers Co. Schuyler Road Plant East Syracuse, NY	3-8G General Crushed Stone Co. Lacona, NY	ACRA - 500
FASS 73-5 FARC 73-121	ROUTE 5 - CAMILLUS BYPASS Fairmount - Camillus - Elbridge	1-AF (51-F) 1976-77	Barrett Paving Jamesville, NY	3-8G General Crushed Stone Co. Lacona, NY	NO ADDITIVE
D95430	ROUTE 227; TOMPKINS COUNTY Perry City - Trumansburg	1-AF 1977-78	Warren Brothers Co. Canoga, NY	2-28G Special Aggregates Corp. Oriskany, NY	ACRA - 500
D95619	I-81; CORTLAND COUNTY Interstate Route 505, Cortland - Tully	1-AF 1978-79	Concrete Matls., Inc. Homer, NY	3-4G Concrete Materials, Inc. Homer, NY - 100% -	REDI-COAT
D95553	ROUTE 41; ONONDAGA COUNTY Scott - Borodino, Part 1 & 2	1-AF 1978	General Crushed Stone Co. Skaneateles, NY	3-8G General Crushed Stone Co. Lacona, NY	TERMINAL BLENDED ARCO - Kling/Beta 1000 EXXON - Pave Bond Spec.
ONONDAGA EAST	MAINTENANCE PROJECT - ROUTE 80 Syracuse City Line to ¼ mile north of Lyons Den Road	1-AF 1977	General Crushed Stone Co. Jamesville, NY	3-8G General Crushed Stone Co. Lacona, NY	TERMINAL BLENDED ARCO - Kling/Beta 1000 EXXON - Pave Bond Spec.
D95064	ROUTE 5; ONONDAGA COUNTY Syracuse - Fayetteville	1-AF 1976-77	Barrett Paving Jamesville, NY	6-13G Allied Chemical, Nichols, NY 3-8G General Crushed Stone Co. Lacona, NY	TERMINAL BLENDED (1976) ARCO - Kling/Beta 1000 (1977) ARCO - Kling/Beta 1000 MARATHON ? (Tonawanda)

ANTI-STRIPPING ADDITIVE INVESTIGATION

CONTRACT NUMBER:	LOCATION:	MIX: PLACED:	PLANT:	HIGH FRICTION AGGREGATE:	ADDITIVE:
ONONDAGA EAST	MAINTENANCE PROJECT - ROUTE 298 From Taft Road to 0.8 miles south of Route 31 at Bridgeport	1-AF 1978	Barrett Paving Jamesville, NY	3-20G Polkville Crushed Stone Polkville, NY 3-8G General Crushed Stone Co. Lacona, NY	TERMINAL BLENDED ARCO-KLING/BETA 1000 (Three Rivers) ARCO ? (Albany) MARATHON ? (Tonawanda)
FARC 71-50 FASH 71-3 FIRC 71-51	ROUTE 5 - CAMILLUS BYPASS Fairmount - State Fair (I-690)	1-AF (51-MF) 1973-74	Barrett Paving Jamesville, NY	3-8G General Crushed Stone Co. Lacona, NY	NO ADDITIVE
D95128	I-690; ONONDAGA COUNTY Lake Onondaga West Shore Development City of Syracuse: State Fair Boulevard	1-AF 1978	General Crushed Stone Co. Jamesville, NY	3-8G General Crushed Stone Co. Lacona, NY	TERMINAL BLENDED EXXON-Pave Bond Spec. ARCO-Kling/Beta 1000
D95763	I-690; ONONDAGA COUNTY Bear Street to Clinton Street	7F 1978	Warren Brothers Co. Schuyler Road Plant East Syracuse, NY	2-28 Special Aggregates Corp. Oriskany, NY	ACRA - 500
		1979	Warren Brothers Co. Clockville, NY	2-28 Special Aggregates Corp. Oriskany, NY	ACRA - 500
D95042	I-481; ONONDAGA COUNTY Forest Interchange - Jamesville	1-AF 1977	General Crushed Stone Co. Jamesville, NY	3-8G General Crushed Stone Co. Lacona, NY	NO ADDITIVE
		1979	-ditto-	-ditto-	EXXON-Pave Bond Spec.

ANTI-STRIPPING ADDITIVE INVESTIGATION

CONTRACT: NUMBER:	LOCATION:	MIX: PLACED:	PLANT:	HIGH FRICTION AGGREGATE:	ADDITIVE:
D95143	I-81; ONONDAGA COUNTY City of Syracuse: Oswego Blvd. SH C56-11;	1-AF 1977-78	Barrett Paving Jamesville, NY	(1977) 3-8G General Crushed Stone Co. Lacona, NY	TERMINAL BLENDED (1977) ARCO-Kling/Beta 1000 MARATHON ? (Tonawanda)
				(1978) 3-20G Polkville Crushed Stone Polkville, NY 3-8G General Crushed Stone Co Lacona, NY	(1978) ARCO-Kling/Beta 1000 (Three Rivers) ARCO ? (Albany) MARATHON ? (Tonawanda)

NOTE:

Re: CORES TAKEN ON D 95042

Mile Marker 2002 - N.B. - NO ADDITIVE USED
Paved September 1977 - Opened to traffic (two-way): October 1977

Mile Marker 2002 - S.B. - NO ADDITIVE USED
Paved October 1977 - Opened to traffic: November 1979

Check out these cores

the one with the antistrip additive.

APPENDIX B

REGION 3: TEST CORE RESULTS

CONTRACTS WITH ANTI-STRIPPING ADDITIVE

CONTRACT	LOCATION	MIX PLACED	PLANT	AGGREGATE	ADMIXTURE	CORE NUMBER	GRADATION % PASSING 1"	1/2"	1/4"	1/8"	#200	#4	#80	#200	AC Cont.	#/ft.^{3} Density	% Air Voids	Pen. 77°F	Viscosity 140°F	Viscosity 275°F
D95064	Route 5; Onondaga County Syracuse - Fayetteville	1 AF 1976-77	Barrett Paving Jamesville	6-13G Allied Chem. 3-8G Lacona	Kling-Beta 1000	37	100	100	82.8	56.4	24.1	16.4	10.4	7.3	6.8	138.8	9.11	26	10281	748
						38	100	100	83.5	57.7	26.6	18.0	11.5	7.7	6.4	136.6	10.54	24	12578	780
*	Dirty fines many uncoated coarse agg. good coating overall					39	100 / 100	100 / 100	82.3 / 82.8	48.5 / 54.2	18.3 / 23.0	12.8 / 15.7	9.8 / 10.5	6.4 / 7.1	7.1 / 6.7	139.5 / 138.3	9.15 / 9.60	23 / 24.3	14733 / 12530	854 / 797
**	Good shape, heavily traveled Poor longidinal joint reflective cracks in driving lane (transverse)																			
***	7/81 - same as reported 8/80																			
Maint.	Route 298 From Taft Rd. to .8 miles south of Route 31 at Bridgeport	1 AF 1978	Barrett Paving Jamesville	3-20G Polkville 3-8G Lacona	Kling-Beta 1000	43	100	100	85.7	56.4	24.0	16.4	10.9	7.8	7.5	146.6	4.00	51	4478	631
						44	100	100	87.6	58.2	24.9	16.8	12.1	8.9	7.5	147.0	4.03	49	4624	637
*	Good to excellent coating					46	100 / 100	100 / 100	87.3 / 86.8	51.7 / 55.4	21.1 / 23.3	14.3 / 15.8	9.7 / 10.9	6.4 / 7.7	7.0 / 7.3	147.6 / 147.0	3.55 / 3.86	50 / 50	4528 / 4543	623 / 630
**	Appears in excellent shape No distress showing																			
D95128	I-690 Onondaga County Lake Onondaga West Shore	1 AF 1978	General Crush Jamesville	3-8G General Crush. Lacona	Pave Bond Spec. Kling-Beta 1000	51	100	100	80.1	50.7	21.9	14.0	9.0	6.4	6.9	144.0	5.76	31	8115	691
						52	100	100	78.3	50.7	21.9	13.9	8.8	6.3	7.2	147.1	3.16	37	5906	624
*	Good to excellent coating					54	100 / 100	100 / 100	82.1 / 80.1	56.5 / 52.6	23.9 / 22.5	15.6 / 14.5	10.1 / 9.3	7.8 / 6.8	5.8 / 6.6	145.8 / 145.6	4.38 / 4.43	33 / 33.6	6453 / 6826	631 / 648
**	Good condition - some flushing in wheelpath (isolated). Poor longitudinal joint																			
***	7/81 - Condition is same as previously reported																			
D95143	I-81; Onondaga County City of Syracuse, Oswego Blvd.	1 AF 1977-78	Barrett Paving Jamesville	3-8G General Crush. Lacona	Kling-Beta 1000	68	100	100	88.8	58.0	22.3	15.1	10.2	7.0	7.0	139.2	8.83	38	6943	688
						69	100	100	77.6	57.0	23.6	15.0	9.8	6.7	6.7	145.0	5.30	40	4942	591
*	Stripping on some coarse agg. Fair to poor overall on coarse agg. Dirty fines, (Very)					70	100 / 100	100 / 100	75.0 / 80.4	55.2 / 56.7	22.0 / 22.6	14.3 / 14.8	8.8 / 9.6	5.6 / 6.4	6.9 / 6.8	144.3 / 142.8	5.75 / 6.62	41 / 39.6	5025 / 5636	618 / 632
**	Good to excellent condition Poor longitudinal joint in some areas. No visible sign of distress																			
***	7/81 - Maybe some minor rutting Same condition as previously reported.																			
D95042	I-481; Onondaga Coutny Forest Interchange-Jamesville	1 AF 1977	General Crush. Jamesville	3-8G Lacona	Exxon Pave Bond Spec.	61	100	99.3	84.9	56.1	20.5	12.8	8.0	5.5	7.5	139.0	9.10	29	13998	921
						62	100	99.5	80.0	43.7	19.4	12.9	8.4	5.6	7.6	142.1	6.95	33	11574	824
*	Good to excellent coating on all aggregate - few fine sandstone particles not coated.					63	100	99.2	82.3	45.0	20.0	13.5	9.0	6.3	7.2	141.1	7.82	30	12601	885
**	8/4/80 - Good to excellent condition - No visible signs of distress					64	100 / 100	100 / 99.5	85.5 / 83.1	56.0 / 50.2	20.8 / 20.1	12.9 / 13.0	7.6 / 8.2	5.2 / 5.6	7.2 / 7.3	138.3 / 140.1	9.51 / 8.34	33 / 31.2	11156 / 12332	820 / 862
***	Some longitudinal cracks appearing in between wheelpath driving lane minor popouts. Overall good to excellent. Few fat spot in passing lane.																			

*Visual Coating Evaluations
**Visual Pavement Condition 8/80
***Visual Pavement Condition 3/81

CONTRACTS WITH ANTI-STRIPPING ADDITIVE

CONTRACT	LOCATION	MIX PLACED	PLANT	AGGREGATE	ADMIXTURE	CORE NUMBER	GRADATION % PASSING 1"	1/2"	1/4"	1/8"	#200	#40	#80	#200	AC Cont.	#/ft.^{3} Density	% Air Voids	Pen. 77°F	Viscosity 140°F	Viscosity 275°F
D95431	Route 5, Onondaga County Elbridge - Camillus, Part 2 Camillus - Fairmont, Part 1, 2	1-ACF 1977	Warren Bros. Schuyler Rd.	3-8G Lacona	Acra-500	2	100	100	94.5	55.7	28.9	21.8	11.5	6.8	7.6	146.2	2.38	38	4887	588
						3	100	100	93.9	53.8	27.3	20.6	12.1	6.2	8.2	146.8	2.28	51	3264	502
*Visual Coating Evaluations	Good to Excellent Coating					4	100 100	100 100	92.1 93.5	50.6 53.3	25.5 27.2	19.3 20.5	10.6 11.4	6.3 6.4	8.2 8.0	145.9 146.3	2.46 2.37	50 46	3052 3734	480 523
**Visual Pavement Condition	8/80 Pavement appears excellent shape Very little reflective cracking Some wheel ruts (less than 1/4")																			
***Visual Pavement Condition	3/81 Condition is same as reported previously																			
D95430	Route 227; Tompkins County Perry City - Trumansburg	1 AF 1977-78	Warren Bros. Canoga, NY	2-38G Special Aggregate	Acra-500	13	100	100	86.1	57.0	22.6	14.4	9.1	6.4	6.3	137.7	10.28	27	11417	864
						14	100	100	86.7	57.9	23.4	14.4	9.0	6.2	6.4	141.2	8.16	35	6355	706
*	Good Coating #13, 14 Some dirty uncoated Agg. #17					17	100 100	100 100	82.4 85.0	53.8 56.2	20.4 22.1	13.6 14.1	9.3 9.1	6.3 6.3	5.8 6.1	139.0 139.3	9.55 9.33	28 29.6	11642 9804	885 818
**	Appears in excellent shape Minor longitudinal cracks in outside wheelpath																			
***	7/81 - Same as 8/80 appearance																			
D95619	I-81; Cortland County Int. Route 505, Cortland-Tully	1 AF 1978-79	Concrete Mat. Homer	3-4G Concrete Mat.	Redi-Coat	20	100	100	77.9	38.3	24.2	18.0	8.1	4.6	6.5	146.5	3.06	38	4559	517
						21	100	100	82.3	37.8	22.2	16.5	8.7	4.1	6.2	145.9	3.71	42	5411	599
*	Good to excellent coating					22	100 100	100 100	78.1 79.4	40.0 38.7	23.4 23.2	17.2 17.2	8.0 8.2	4.0 4.2	6.6 6.4	144.6 145.6	3.70 3.49	46 42	4160 4743	529 598
**	Excellent condition - Some transverse and reflective cracking. Some cracking in longitudinal joint.																			
***	7/81 - Some raveling in wheelpaths (Driving), Contamination-NB Lane water pumping through. Overall good.																			
D95553	Route 41, Onondaga County Scott-Borodino Part 1 & 2	1 AF 1978	General Crush Skaneateles	3-8G Lacona	Kling-Beta 1000 Pave Bond Spec.	23	100	100	80.9	66.4	27.9	17.6	10.5	7.5	7.0	136.5	10.25	32	10966	829
						24	100	100	82.4	66.7	27.5	16.9	10.6	7.2	6.9	137.7	9.33	32	10612	818
*	Many uncoated fine agg. Overall poor to fair Some dirty aggregate					26	100 100	100 100	82.5 81.9	63.1 65.4	27.7 27.7	17.8 17.4	11.0 10.7	7.0 7.2	6.4 6.7	139.0 137.7	9.36 9.64	25 29.6	18058 13212	1019 888
**	Appears in excellent shape Some coarse agg. (#1) popping out Top separated easily from binder																			
Maint.	Route 80 Syracuse City Line to 1/4 Mi. North of Lyons Den Road	1 AF 1977	General Crush Jamesville	3-8G Lacona	Kling-Beta 1000 Pave Bond Spec.	29	100	100	86.6	61.7	23.1	14.6	9.2	6.5	5.9	143.5	7.45	22	16276	882
						30	100	100	84.1	59.8	21.8	13.6	8.4	6.4	6.1	142.6	8.12	24	17020	929
*	Some uncoated fines Some coarse agg. Stripped Overall fair to good					33	100 100	100 100	88.3 86.3	65.5 62.3	26.8 23.9	15.9 14.7	9.1 8.9	6.0 6.3	5.3 5.7	138.0 141.3	11.56 9.04	23 23	24263 19136	1078 963
**	8/80 - Good to excellent shape No visible signs of distress																			
***	Condition same as 8/80																			

*Visual Coating Evaluations
**Visual Pavement Condition 8/80
***Visual Pavement Condition 3/81

CONTRACTS WITHOUT ANTI-STRIPPING ADDITIVE

CONTRACT	LOCATION	MIX PLACED	PLANT	AGGREGATE	ADMIXTURE	CORE NUMBER	GRADATION % PASSING 1"	1/2"	1/4"	1/8"	#200	#40	#80	#200	AC Cont.	#/ft.^{3} Density	% Air Voids	Pen. 77°F.	Viscosity 140°F	Viscosity 275°F
D95897	Route 11 From Rte. 342 - Evan Mills (Region 7)	1 ACF 1978	General Crush. Watertown	General Crush. Lacona	None	77	100	100	99.0	71.1	26.7	16.8	10.2	6.4	6.9	140.6	7.63	47	3264	461
						81	100	100	99.3	70.7	27.9	17.3	10.6	6.5	6.6	138.5	9.32	39	4550	515
*Visual Coating Evaluations	Very Good Coating					82	100/100	100/100	98.3/98.8	70.8/70.8	27.6/27.4	17.2/17.1	10.1/10.3	6.4/6.4	7.0/6.8	141.2/140.1	7.22/8.00	46/44	3642/3818	479/485
**Visual Pavement Condition	Fair to Good shape overall Some reflective cracking in all lanes - Small areas of flushing.																			
***Visual Pavement Condition	7/81																			
FARC 75-164	Int. 81 Route 342-Thousand Is. Bridge (Region 7)	1 ACF 1976	General Crush. Watertown	Lacona	None	85	100	100	98.6	69.9	25.1	13.8	7.5	4.6	6.3	133.9	12.55	30	8785	639
						86	100	100	98.9	69.5	23.9	13.5	7.0	4.5	7.0	135.4	11.10	31	7619	605
*	Some stripping both coarse and fine agg. Fair to good overall					87	100/100	100/100	90.6/96.0	64.6/67.9	27.0/25.3	17.6/14.9	10.8/8.4	6.7/5.2	6.7/6.6	148.1/139.1	3.42/9.0	58/39	2266/6223	417/553
**	Good to excellent shape. Few flushed areas - No cracks.																			
D95047	Route 12 Clayton - Alex. Bay (Region 7)	1 ACF 1976	General Crush. Watertown	Lacona	None	89	100	100	98.7	74.8	28.5	16.9	9.9	5.9	6.4	135.3	12.08	28	18314	1023
						90	100	100	98.4	75.1	29.2	17.7	10.0	6.1	6.9	136.2	11.16	29	14787	949
*	Good to excellent overall on coating. Couple of coarse Agg. stripped.					94	100/100	100/100	97.8/98.3	73.5/74.4	28.5/28.7	17.5/17.3	9.8/9.9	6.0/6.0	6.0/6.4	136.6/136.0	11.05/11.43	27/28	17922/17007	1037/1003
**	Good to excellent shape. Some reflective cracks, few flushed areas.																			
D95627	Route 12, Clayton - Alex. Bay (Region 7)	1 ACF 1977	General Crush. Watertown	Lacona	None	95	100	100	98.3	67.0	27.6	18.2	11.7	7.7	7.3	141.0	6.92	47	3590	496
*	Good to excellent coating.					96	100	100	99.2	68.3	28.6	18.9	12.4	8.2	6.7	140.6	7.47	39	5610	591
**	Good to excellent shape. Some reflective cracking, very little distress					97	100/100	100/100	99.1/98.8	73.7/69.6	29.4/28.5	19.3/18.8	12.5/12.2	7.9/7.9	6.5/6.8	139.7/140.4	8.54/7.64	39/41.6	6028/5076	596/561
FASS 73-5	Route 5 - Camillus by Pass	1 AF 1976-77	Barrett Paving Jamesville	3-8G General Crush Lacona	None	7	100	100	89.3	57.6	21.9	13.4	8.0	5.1	6.4	135.6	11.81	24	15039	866
FASS 73-121	Fairmount-Camillus-Elbridge					8	100	100	90.5	57.5	21.8	13.5	6.9	5.2	6.4	137.9	10.20	24	14125	837
						10	100/100	100/100	89.8/89.8	56.4/57.1	21.7/21.8	13.7/13.5	8.0/7.6	4.9/5.0	5.9/6.2	134.8/136.1	12.62/11.54	31/26	9055/12939	721/808
*	Some uncoated sandstones Dirty Aggregate Fair coating																			
**	Good to excellent shape Very little rutting. No bond between top & binder. Some cracks in westbound lane. Isolated loss of some surface fines.																			
***	7/81 Same condition as previously reported. Long. cracks in DL maybe subgrade problem.																			

*Visual Coating Evaluations
**Visual Pavement Condition
***Visual Pavement Condition - 7/81

CONTRACTS WITHOUT ANTI-STRIPPING ADDI

CONTRACT	LOCATION	PLACED	PLANT	AGGREGATE	ADMIXTURE	CORE NUMBER	GRADATION % PASSING 1"	1/2"	1/4"	1/8"	#200	#40	#80	#200	AC Cont.	$\#/ft.^3$ Density	% Air Voids	Pen. 77°F	Viscosity 140°F	Viscosity 275°F
FARC 71-50 FASH 71-3	Route 5 - Camillus by Pass	1 AF	Barrett Paving	General Crush Lacona 3-8G	None	47	100	100	83.8	53.2	23.9	17.0	12.2	9.2	7.2	149.4	1.72	41	4397	430
						48	100	100	84.7	54.3	23.6	15.7	10.9	7.8	6.8	147.5	2.92	37	6159	477
FARC 71-51	Fairmont - State Fair (I-690)	1973-74	Jamesville			50	100 100	100 100	83.6 84.0	54.4 53.9	21.7 23.0	13.8 15.5	8.3 10.4	5.7 7.5	6.4 6.8	140.6 145.8	7.85 4.10	30 36	6377 5644	577 494
*	Good coating overall. Some silt in one core did not coat.																			
**	8/4/80 Fair to good shape overall. Poor longitudinal joint. Long cracks in some lanes																			
***	7/81 Same condition as previously reported.																			
D95042	I-481; Onondaga County Forest Interchange - Jamesville	1 AF 1977	General Crush. Jamesville	3-8G Lacona	None	65	100	100	84.0	49.2	20.1	12.2	7.3	5.1	6.7	139.5	8.89	30	16732	940
						66	100 100	100 100	81.4 82.7	46.7 47.9	18.9 19.5	11.7 11.9	6.6 6.9	4.5 4.8	6.8 6.7	138.8 139.1	9.41 9.15	32 31	14331 15531	879 909
*	Good coating coarse agg. Some fine (silt) did not coat.	(Open to traffic in 11/79)																		
**	8/4/80 Good to excellent condition. No visible signs of distress.																			
D95042	I-481; Onondaga County Forest Interchange - Jamesville	1 AF 1977	General Crush Jamesville	3-8G Lacona	None	59	100	100	83.9	51.7	22.6	14.8	9.5	6.6	7.2	143.5	8.78	30	20253	986
						60	100 100	99.4 99.7	81.9 82.9	52.5 52.1	23.0 22.8	15.4 15.1	10.0 9.7	6.9 6.7	7.4 7.3	144.1 143.8	6.25 7.51	30 30	20045 20149	984 985
*	Generally good coating of all aggregate - Some sandstone in the fines are uncoated	(Open to traffic in 10/77)																		
**	8/4/80 Good to excellent condition. No visible signs of distress.																			
***	Some longitudinal cracks appearing in between WP driving lane. Minor popouts. Few flush spots passing lane. Overall good to excellent.																			

*Visual Coating Evaluations
**Visual Pavement Condition
***Visual Pavement Condition - 7/81

APPENDIX C

SPECIAL REPORT 67

STRIPPING SUSCEPTIBILITY OF AGGREGATES FROM TWO SOURCES IN NORTHERN NEW YORK STATE

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STRIPPING SUSCEPTIBILITY OF AGGREGATES FROM TWO SOURCES IN NORTHERN NEW YORK STATE

Richard W. Miller, Senior Civil Engineer

Special Report Prepared Under Research Project 12-7
Conducted in Cooperation With
The U.S. Department of Transportation
Federal Highway Administration

Special Report 67
April 1980

ENGINEERING RESEARCH AND DEVELOPMENT BUREAU
New York State Department of Transportation
State Campus, Albany, New York 12232

I. INTRODUCTION

In March 1979, the Materials Section of the Engineering Research and Development Bureau was asked to assist the Materials Bureau in evaluating the stripping susceptiblity of aggregates from several northern New York sources. These sources were potential candidates for use in two upcoming contracts for resurfacing portions of the Adirondack Northway (I 87) near Chestertown and Elizabethtown, New York. Stripping had occurred in other Northway pavements when aggregate from one of these sources was used (in 1977 and again in 1978) with a commercial anti-stripping agent, even though tests for stripping susceptibility had indicated that it could be used safely.

This report describes work that was performed in the bituminous laboratory of the Engineering Research and Development Bureau from April through June 1979, using a stripping susceptibility test recently developed under an NCHRP contract with the University of Idaho. The tests included two commercial anti-stripping agents plus hydrated lime, at several dosage rates. The report also includes recommendations regarding future use of the aggregates under consideration.

A. Background

The New York State Department of Transportation had planned to resurface major highways into the Lake Placid area, site of the 1980 Winter Olympics, to provide acceptable levels of service for the increased traffic volumes expected. That program included six projects on the Adirondack Northway -- the major north-south route connecting Albany and Montreal, and a major access road to Lake Placid.

In 1977, the first two of the six projects were completed. Within 12 months, distress of the type associated with stripping of asphalt from aggregate particles was observed on one of the two projects. The condition worsened by the spring of 1979. Cores drilled from the pavement confirmed that stripping was the cause of the distress. The second two projects, paved in 1978, appeared in the spring of 1979 to be developing similar symptoms. Significantly, the Department's stripping susceptibility test (60-seconds immersion of loose mix in boiling water) had predicted that the aggregate-asphalt combination used would not result in stripping if a particular proprietary anti-stripping agent were used, and it was. Because this same aggregate source appeared to be the most economical for the two remaining projects, the award date for contracts was delayed, pending completion of this investigation.

Numerous tests have been developed to identify asphalt concrete susceptible to moisture damage. None has been more than moderately successful or has received

wide acceptance, primarily because of a lack of relationship between test and field conditions. There has been considerable interest recently in a new test procedure developed at the University of Idaho under sponsorship of the National Cooperative Highway Research Program (1,2).

The new test is based on comparisons of the tensile strength of dry compacted bituminous-concrete specimens before and after being subjected to two levels of moisture conditioning: 1) VS or vacuum saturation, and 2) FS or vacuum saturation plus one cycle of freezing followed by 15 hours of warm-water soaking. This comparison is expressed as a tensile strength ratio or TSR. Short-term moisture damage, for pavement life up to 24 months, is inferred from TSRs after vacuum saturation alone, according to the test's developers, Long-term moisture damage, for pavement life up to and through 60 months, is inferred from TSRs after vacuum saturation plus freezing and soaking (1).

A TSR of 0.70 was found in earlier work (1) to discriminate between those combinations that field experience had shown to be susceptible to stripping and those that had not (Fig. 1). A later interpretation of the test (2) has been that any loss of tensile strength, expressed by a TSR less than 1.00, predicts potential moisture damage, with the TSR becoming smaller as the damage potential increases. Research under NCHRP sponsorship is continuing at the University of Idaho for further correlation of the results of the new test with field experience (2).

One of the first states to make use of the new procedure was Virginia, where it is currently being implemented (3). Experience in that state with eight aggregates thought to be susceptible to stripping was that seven showed stripping damage after vacuum saturation and FS conditioning (TSR less than 1.00), with six having TSRs less than 0.70. Only one Virginia mix had a TSR more than 1.00 after vacuum saturation alone. Two commercial anti-stripping agents were effective in increasing TSRs of the mixes in which they were used. The Virginia results illustrate the significant influence of void content on the degree of stripping that occurs in the new test (Fig. 2), confirming findings of the NCHRP study and illustrating the importance of reproducing field levels of compaction in laboratory specimens. The amount of stripping observed visually in the Virginia research was also found to be indicative of the measured TSRs.

B. Test Procedures

Begun in April, the laboratory study had to be completed by July 1979 so that a scheduled August contract award could include resulting recommendations. Within that time frame, only 12 batches could be fabricated and tested.

The combination of materials used is given in Table 1. In one batch, a crushed dolomitic aggregate with a history of resistance to stripping was used without additive as a control. The crushed gravel aggregate was typical of other gravels from the area for which experience had been unsatisfactory. In addition to the two proprietary anti-stripping admixtures, identified in this report as Brands A and B, hydrated lime was also used. Dosage rates varied between 0.5 and 1.5 percent. Mixtures were prepared and compacted with aggregate graded as summarized in Table 2. Asphalt content was 6.2 percent.

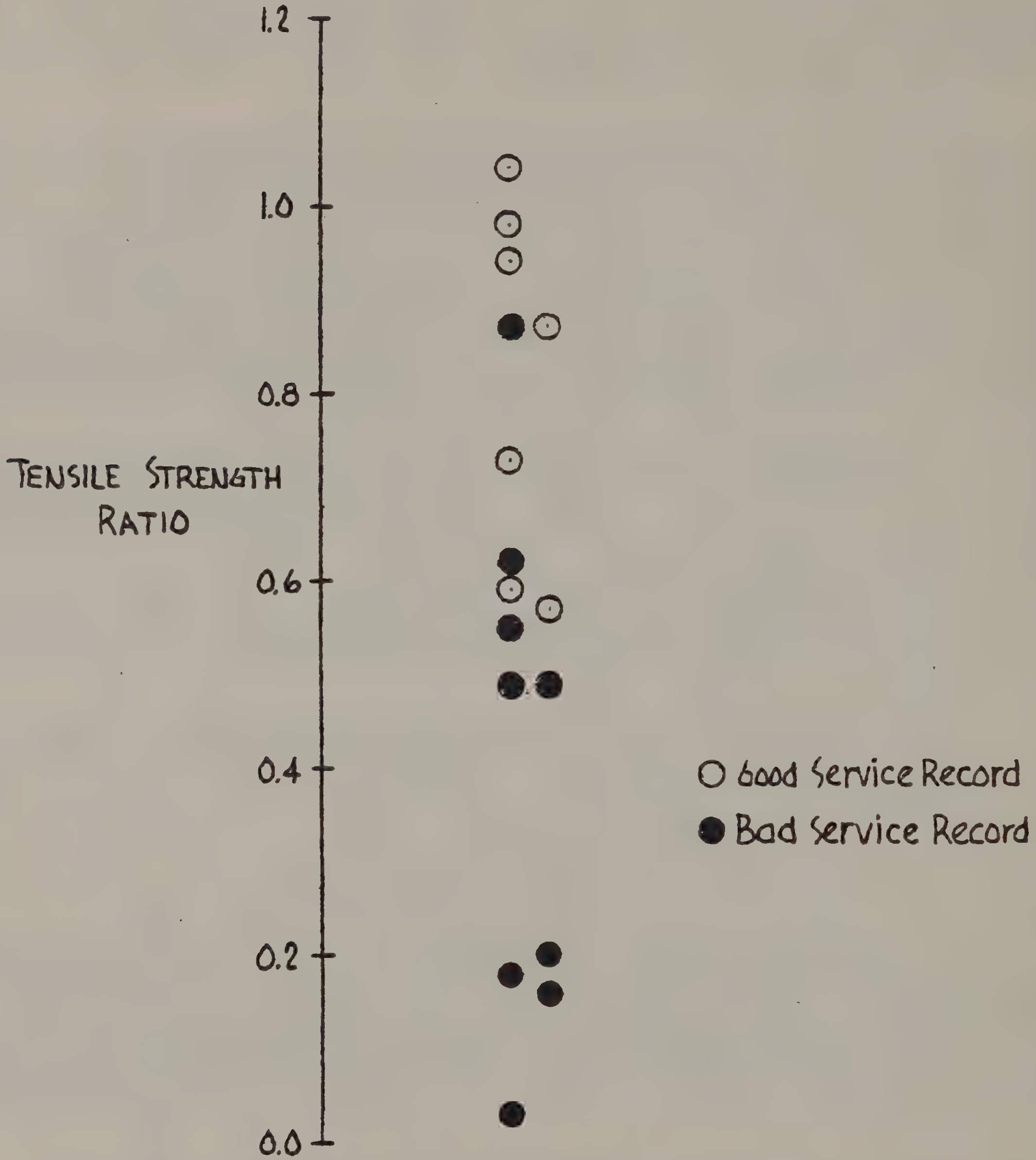


FIGURE 1 RELATIONSHIP BETWEEN TSR AND AGGREGATE SERVICE RECORD (from Fig. 9 Ref. 1)

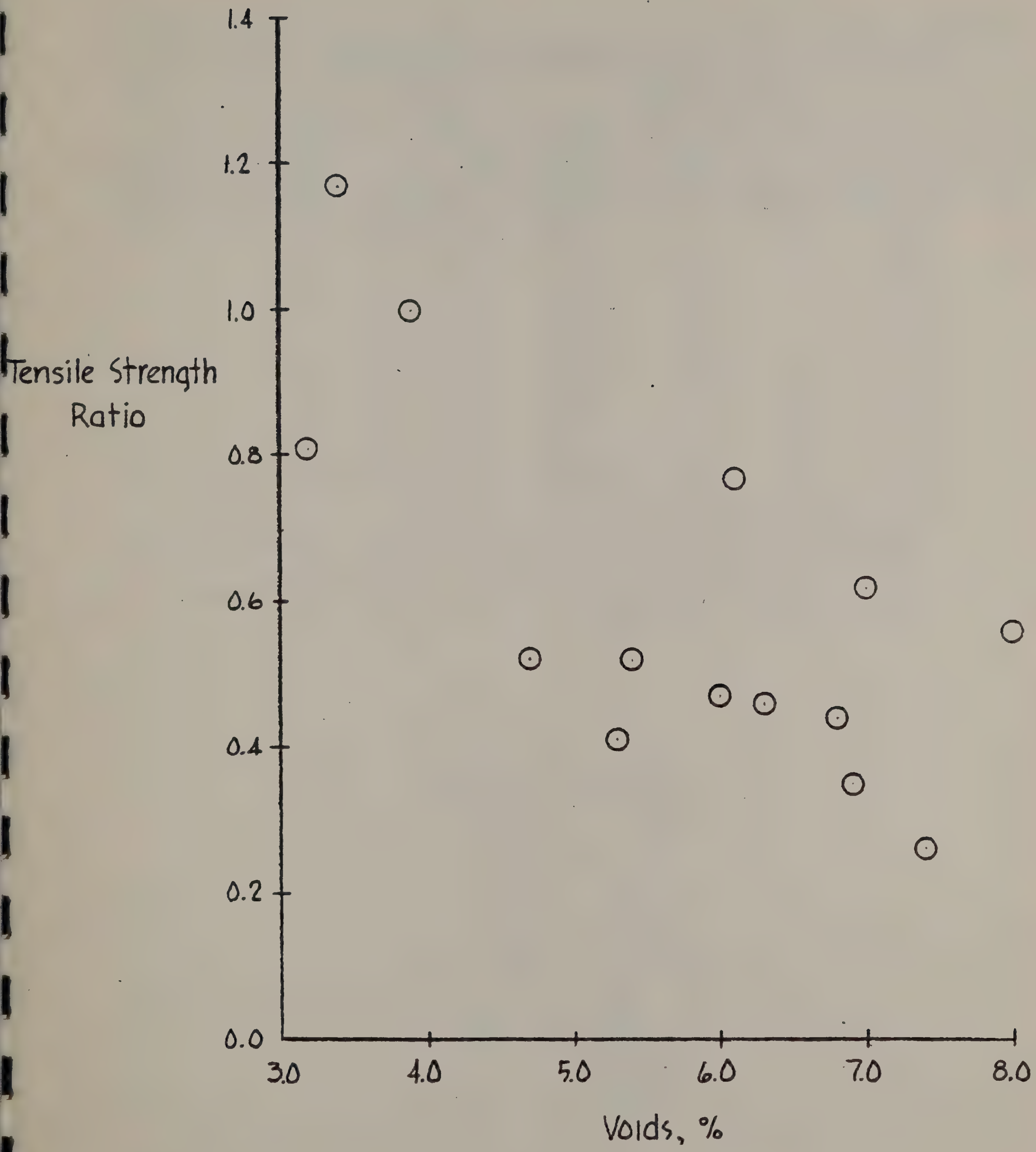


FIGURE 2 RELATIONSHIP BETWEEN TSR AND VOIDS
(from data in Ref. 3, tables 4 and 5)

TABLE 1. MIX MATERIALS AND STRIPPING TEST RESULTS.

Crushed Aggregate	Anti-Stripping Admixture		Asphalt Cement Grade	Tensile Strength Ratio†		Visual Stripping Index	Test Series
	Brand*	Dosage, %**		VS	FS		
Dolomite	None	—	AC-10	1.06	1.09	4.6	6
Gravel	None	--	AC-10	1.03	0.90	1.8	3
Gravel	B	0.5	AC-10	0.96	0.95	4.1	5
Gravel	B	1.0	AC-10	0.92	0.91	4.3	0
Gravel	A	0.5	AC-10	0.97	0.97	3.8	4
Gravel	A	1.0	AC-10	1.04	1.02	4.6	1
Gravel	A	1.0	AC-10	1.01	1.00	4.3	10
Gravel	A	1.5	AC-20	0.93	0.89	3.8	11
Gravel	HL	0.5	AC-10	0.91	0.93	2.1	8
Gravel	HL	1.0	AC-10	0.95	0.77	2.3	7
Gravel	HL	1.0	AC-10	0.95	0.63	1.3	12
Gravel	HL	1.5	AC-10	1.02	0.95	2.5	9

*HL = hydrated limestone.

**Admixtures A and B by weight of asphalt cement, hydrated lime by weight of aggregate.

†Each value is the average of results of tests on four samples molded from the same batch.

TABLE 2. MIX DESIGN.

Sieve Size	Percent Passing
1 in.	100.0
1/2 in.	97.5
1/4 in.	72.0
1/8 in.	50.0
No. 20	27.0
No. 40	14.0
No. 80	7.0
No. 200	4.0
Asphalt Content, %	6.2

Procedures used to prepare and test the specimens were those developed by Lottman (1), as modified by Maupin (3). A total of 20 specimens were fabricated for each batch to ensure that a minimum of 12 would be within the target void content, 3.0 to 4.0 percent for the gravel-aggregate mixes. This range was selected to yield a mean value equal to or greater than that for 90 percent of the cores extracted from damaged pavements built with this aggregate. The dolomitic-aggregate mixes were targeted for void contents of 5.0 to 6.0 percent, approximating void contents experienced for that mix in the field. Splitting tensile strengths were measured at 77 F using standard Marshall testing apparatus with a loading rate of 2 in./min.

II. RESULTS AND DISCUSSION

A. Results

The results of all tests on mixes and recovered asphalt for the 12 batches are given in Table 3. Tensile strength ratios (Table 1) were determined by dividing the tensile strength of conditioned specimens, VS or FS, by the tensile strength of dry specimens. As suggested by Lottman (2), a TSR of 1.00 or more was taken to indicate no stripping potential, less than 1.00 some stripping potential, and less than 0.70 an unacceptable stripping potential.

Predicted short-term (0 to 2 years) stripping potentials (after VS conditioning only) were all greater than 0.90, indicating (according to the recommended interpretation) that any moisture-induced damage that did occur would be minor. Predicted long-term (2 to 5 years) stripping potential (after FS conditioning) ranged from 0.63 to 1.09, indicating (according to the recommended interpretation) that moisture-induced damage would vary from unacceptable to none. Only hydrated lime at 1.0-percent concentration (Series 12) indicated an unsatisfactory stripping potential (TSR below 0.70).

TSRs were found to vary considerably, as shown by the coeficients of variation for tensile strengths in Table 4. Lottman (2) reported a range of coefficients of variation of 7.8 to 19.5, compared to 1.07 to 27.20 in this study. Except for one (Series 12, FS), all in this study were less than 13.00. A within-test standard deviation for tensile strength of 4.8 psi was estimated (in the usual manner) for the 36 groups of 4 tests each. Any values of TSR must be viewed with this testing error in mind.

B. Discussion

Effectiveness of the anti-stripping admixtures was determined by comparing TSRs of the gravel-aggregate series in which the admixtures were used to the gravel-aggregate series (No. 3) with no admixture, fabricated to represent pavement conditions in which stripping had been observed. TSRs greater than those for Series 3 were taken to indicate those admixture-dosage combinations that should be effective in reducing or eliminating stripping.

It is interesting to note that TSRs for Series 3 were 1.03 and 0.90, respectively, for the short- and long-term evaluations. Recalling that stripping was observed on I 87 within 2 years, TSRs for Series 3 should have both been less than 1.00 to be consistent. Visual examination of the tested specimens showed stripping of asphalt in samples from both — considerable in the FS specimens, and less in the VS specimens. Variations in the tensile strength measurements noted

TABLE 3. ASPHALT CONSISTENCY AND TENSILE STRENGTH.

Test Series	Mean Voids, %[a]	Asphalt Consistency: Original[b] Pen. (77 F), mm	Visc. (140 F), P	Visc. (245 F), cSt	After Conditioning[c] Pen. (77 F), mm	Visc. (140 F), cSt	Visc. (275 F), P	Tensile Strength, psi[d] Dry	VS	FS
0	3.24	87	1130	314	34	9,166	699	80.6	73.9	73.2
1	3.47	87	1130	314	32	9,093	543	72.3	75.1	73.7
3	4.08	87	1130	314	34	11,076	738	68.3	70.2	61.4
4	3.71	87	1130	314	32	11,858	746	77.8	75.3	75.6
5	3.83	87	1130	314	32	11.752	770	78.0	75.0	74.4
6	5.32	87	1130	314	38	6,856	705	65.5	69.6	71.4
7	2.99	87	1130	314	50	2,919	479	91.0	86.8	69.8
8	3.75	87	1130	314	49	3,054	486	83.8	76.5	77.8
9	3.25	87	1130	314	53	2,865	499	82.2	83.8	78.1
10	4.00	87	1154	321	33	11,781	811	76.4	77.0	70.2
11	4.34	--	--	--	28	54,857	1486	101.6	94.3	90.0
12	3.81	87	1154	321	52	2,907	493	84.6	80.7	53.1

[a] Each value is the average of results of tests on eight different samples.
[b] Result of a single test on each lot of asphalt (all were AC-10, but Series 11 which was AC-20).
[c] Each value is the result of a single test on one aged sample for each series.
[d] Each value is the average of the results of tests on four different samples.

TABLE 4. VARIATIONS IN SPLITTING TENSILE STRENGTH.

Aggregate And Admixture	Dosage, %	Coefficient Of Variation Dry	VS	FS	Test Series
Crushed Dolomite					
None	None	2.67	2.05	6.54	6
Crushed Gravel					
None	None	5.45	9.60	8.79	3
Brand A	0.5	5.46	12.34	8.71	4
Brand A	1.0	4.72	8.70	8.20	1
Brand A	1.0	8.21	5.13	4.03	10
Brand A	1.5	3.93	2.73	4.27	11
Brand B	0.5	1.53	2.10	3.14	5
Brand B	1.0	11.60	2.70	1.49	0
Hydrated Lime	0.5	5.51	6.60	6.20	8
Hydrated Lime	1.0	6.89	10.90	11.20	7
Hydrated Lime	1.0	4.70	9.65	27.20	12
Hydrated Lime	1.5	1.07	1.61	6.51	9

earlier in this chapter were great enough to account for this discrepancy between test results and field experiences. Because time constraints did not allow duplicate batches to be fabricated, this explanation was not tested.

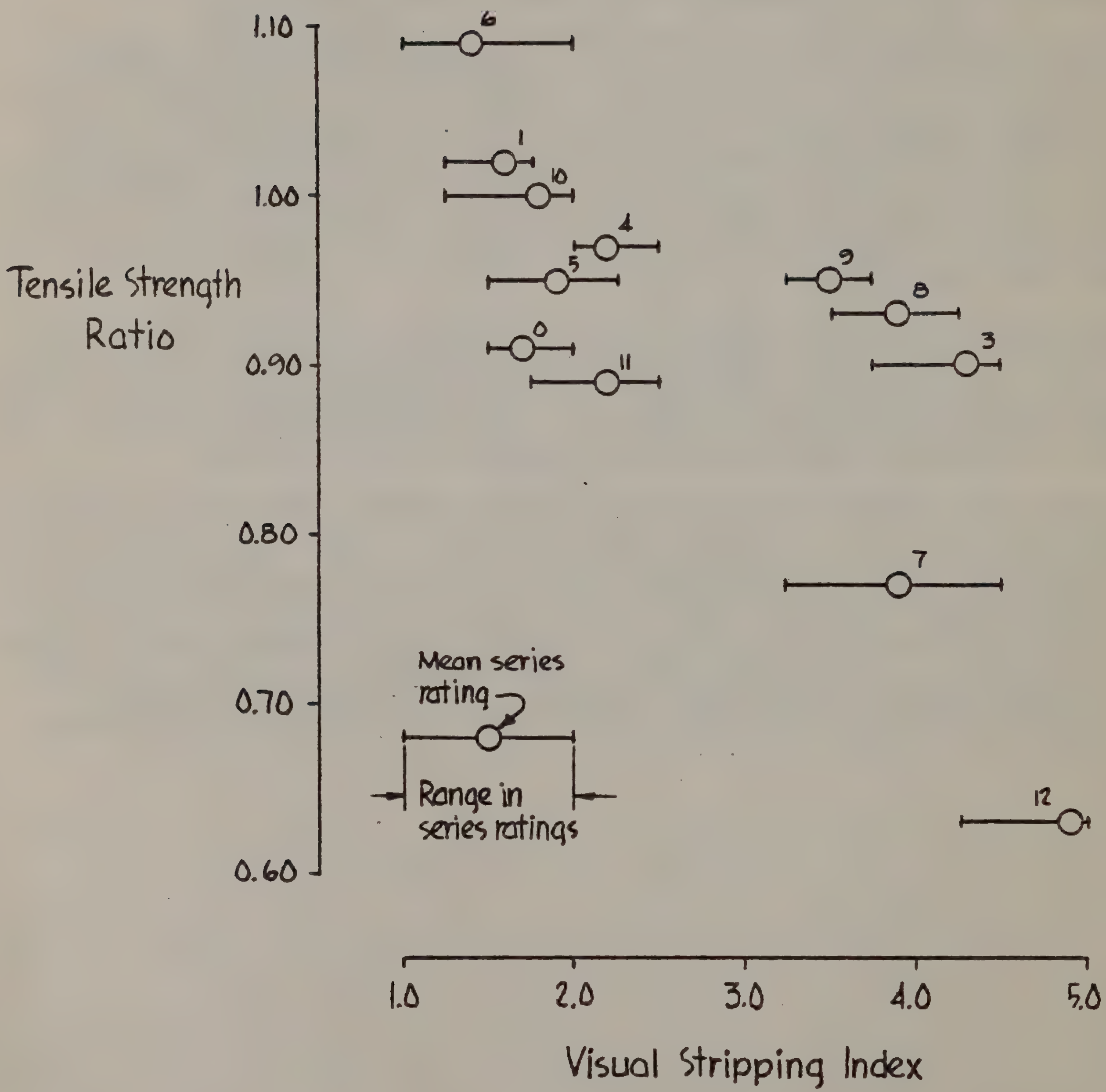
Comparisons between the gravel-aggregate series with additives and Series 3 indicated that only one admixture -- Brand A at 1.0-percent dosage -- was effective in reducing or eliminating stripping in both the VS and FS evaluations. A duplicate batch (Series 10) confirmed these results. Visual examination showed only minor stripping for dry, VS, and FS specimens.

Use of other admixtures and Brand A at 0.5 percent dosage were determined to be less effective in reducing stripping potential. Brand B resulted in TSRs between 0.91 and 0.96 for both VS and FS tests, but visual examination of the specimens showed stripping for both conditioning processes. Hydrated lime, which has been reported effective in reducing stripping with some aggregates, was ineffective for these gravels. Curiously, FS specimens with hydrated lime were stripped worse than similar specimens without additives. Use of hydrated lime has one advantage in that it reduced asphalt hardening (Table 3), which has also been reported.

The dolomitic aggregate (Series 6) was a candidate alternative aggregate, and had been included in the testing program as a material with a good performance history with respect to stripping. Its TSR values were 1.06 and 1.09 for short- and long-term evaluations, respectively -- the highest of all the series. Visual examination of these specimens showed no evicence of stripping.

Each of the specimens preconditioned by FS was visually inspected to determine the relative extent of stripping and a subjective rating of 1 to 5 was assigned, where 1 was the least amount of stripping and 5 the most. The average of four independent ratings (four different persons evaluated each specimen) constituted the "Visual Stripping Index" for that specimen (Table 1). All gravel-aggregate samples showed some stripping. Only the dolomite-aggregate sample (Series 6) showed none. These indices for the four FS specimens for each batch were then averaged and plotted against TSRs for long-term potential in Figure 3. There was a general relationship that as this index increased, TSR decreased.

FIGURE 3 CORRELATION BETWEEN TSR AND VISUAL STRIPPING INDEX



III. SUMMARY

Stripping potential of aggregate from two sources was evaluated. Aggregate from one source was also evaluated with different dosages of three different anti-stripping admixtures. Stripping potential was evaluated on the basis of indirect tensile strength tests from which tensile strength ratios (TSRs) were determined after two different simulated exposure treatments. On the basis of TSRs and visual evaluation of the test samples, the following conclusions are drawn:

1. The only admixture that improved TSR in both short- and long-term evaluations from that when no admixture was used was Brand A at a 1.0-percent dosage. When used at 0.5 percent, it was less effective than when no admixture was used.

2. Brand B when used at either 0.5 or 1.0 percent was not effective in improving the TSR in the short-term evaluation, but did improve it in the long-term evaluation.

3. Hydrated lime was ineffective at 0.5, 1.0, and 1.5 percent in the short-term evaluation, and in the long-term evaluation improved the TSR at dosage rates of only 0.5 and 1.5 percent.

4. The dolomitic aggregate had the highest TSR of all the batches.

5. Visual examination of the FS specimens showed some signs of stripping for all batches except when dolomitic aggregate was used.

Based on this study's results, it was recommended that if locally available gravel aggregates are to be used, 1.0-percent Brand A by weight of asphalt cement should be used as an anti-stripping agent. However, because there was visual evidence of stripping in the specimens, it could not be assumed that stripping would not occur. It was recommended, based on test results and performance history, that the dolomitic aggregate be used if it could be justified economically.

REFERENCES

1. Lottman, R. P. Predicting Moisture-Induced Damage to Asphaltic Concrete. Report 192, National Cooperative Highway Research Program, Transportation Research Board, 1978.

2. Lottman, R. P. Predicting Moisture-Induced Damage to Asphaltic Concrete: Field Evaluation Phase. "Summary Interim Report" on NCHRP Project 4-8(3)/1, University of Idaho, February 1979. Unpublished.

3. Maupin, G. W., Jr. "Implementation of Stripping Test for Asphaltic Con-Concrete." Transportation Research Record 712, Transportation Research Board, 1979, pp. 8-12.

APPENDIX D

REGION 1: VISUAL OBSERVATIONS AND REPORT

MEMORANDUM
DEPARTMENT OF TRANSPORTATION

DATE July 13, 1979

SUBJECT ASPHALT CONCRETE PAVEMENT PERFORMANCE

FROM W. J. Brule WJB

TO J. J. Murphy

On July 9-10, T. Wohlscheid, P. Ducharme, R. Brady and I inspected the performance of several asphalt concrete pavements in the Adirondack Mountains area. The purpose of the inspection was to determine if the distress occurring on the Northway, due to stripping of asphalt from crushed gravel particles, occurs in other pavements in the area. The results of the inspection showed that the overall performance of the asphalt concrete pavements on the primary and secondary roads was relatively good. The distress on the Northway, which is occurring in the pavement constructed with the same or similar materials, is unique to that roadway.

The inspection included observations of pavements consisting of crushed gravel, iron ore mine tailings, granite, and limestone. We dug into the pavement to inspect the adhesion of asphalt to the aggregate particles. Attached is a record of the observations at each site inspected.

An analysis of the data shows that adhesion of asphalt to the aggregate is very good for limestone and iron ore mine tailings. The adhesion of asphalt to gravel and crushed granite aggregate particles ranges from very poor to good. The most important single factor relating to the degree of adhesion appears to be the relationship between traffic volume, density and speed. Pavement in the wheel paths showed severe stripping, in most cases, whereas pavement between wheel paths was relatively less. The passing lane on the Northway showed less stripping than the driving lane also. The asphalt concrete on the Northway shoulders and the U-turns showed no stripping.

It was noted that the use of chemical anti-stripping additive (Kling-Beta) did not prevent the occurrence of stripping. If one did not know that the anti-stripping additive had been added to certain pavements, it is very doubtful that one could tell the difference between pavements with and without it.

Based on the findings in this pavement inspection, we have determined that all gravels in the Adirondack Mountains area will lose adhesion between the asphalt and aggregate particle in areas subjected to

wheel passes. It appears that the hydraulic pressures induced in the pavement pores by tires passing over wet pavement is the primary cause for stripping. Conversely, areas exposed to the same environmental conditions, but no appreciable traffic, exhibit little or no stripping.

It is interesting to note a comment made by Mr. Charles R. Foster in the discussion following the report "Asphalt Stripping" by H. J. Fromm published in the 1974 proceedings, Association of Asphalt Paving Technologists. The comment is as follows:

> "I think most of the stripping that we get in the pavements is the result of work rather than spontaneous emulsion. I've seen bad stripping in the traffic lane with no stripping outside the traffic lane."

Mr. Foster's comment leads me to believe that the asphalt stripping problem has been with us for a long time. We may be faced with the situation where paving mixtures prone to stripping are being subjected to increased traffic and the distress is appearing as a result.

In conclusion, we believe that the gravel aggregates in the Adirondack Mountains area should continue to be used in asphalt concrete pavements on the primary and secondary road system without any limitations. We also believe that chemical anti-stripping additives should be used only experimentally on selected projects until a determination can be made as to their effectiveness.

WJB:FS
File: 13

Attachment

PAVEMENT INSPECTION 7/9/79

Mile Post	Pavement Age, Yrs	Mix Type	Coarse Aggregate	Stripping Asphalt/Aggregate	Pavement Condition	Remarks
87I NB 1710 1286	2	1A Top	Crushed Gravel Peckham, Chestertown	Driving Lane(WP)-Severe Passing Lane(WP)-Very Little Shoulders - None	Fair	Kling Beta Additive Ripples in pavement surface
87I NB 1710 1288	2	1A Top	Crushed Gravel Peckham, Chestertown	Driving Lane(WP)-Severe Passing Lane(WP)-Little Shoulders - None	Good	Kling Beta Additive
87I NB 1710 1328	2	1A Top	Crushed Gravel Peckham, Chestertown	Driving Lane(WP)-Severe (BWP)-Moderate (Edge)-Slight Passing Lane(WP)-Mod/Severe (BWP)-Slight	Fair/Good	Kling Beta Additive Top course transverse construction joint was distorted in wheel paths with movement in direction of travel
87I NB 1710 1329	2	1A Top	Crushed Gravel Peckham, Chestertown	U-Turn Area - None/Slight	Good	Kling Beta Additive
87I NB 1710 1336	2	1A Top	Crushed Gravel Peckham, Chestertown	Driving Lane(WP)-Severe Passing Lane(WP)-Mod/Severe Shoulders - None	Good	Kling Beta Additive
87I NB 1710 1362	2	1A Top	Crushed Gravel Peckham, Chestertown	Driving Lane(WP)-Severe	Fair	Kling Beta Additive Pot holes developing in driving lane - only one appears to be caused by contamination

Mile Post	Pavement Age, Yrs.	Mix Type	Coarse Aggregate	Stripping Asphalt/Aggregate	Pavement Condition	Remarks
87I SB 1211 1039	1	1A Top	Crushed Gravel Peckham, Chestertown	Driving Lane (WP)-Severe (BWP)-Moderate Passing Lane (Edge)-Slight (WP)-Severe (BWP)-Slight	Good	Kling Beta Additive Drum Mix Plant
87I SB 1211 1074	1	1A Top	Crushed Gravel Peckham, Chestertown	Driving Lane (WP)-Severe Passing Lane (WP)-Moderate/Severe	Good	Kling Beta Additive SB entrance ramp had slight stripping in the wheel path
87I SB 1211 1201	12 est.	1A Top	Iron Ore Mine Tailings	Driving Lane (WP)-Very Little	Fair	Pavement has many cracks
Route 8 Chestertown-Hauge	4	1A Top	Crushed Gravel Peckham, Chestertown	(WP)-Slight/Moderate	Good	RCR 74-179
Route 8 Chestertown-Hauge	10 est	1A Top	Crushed Granite Chestertown	(WP)-Slight	Good	
8 1710 1228	10 est	1A Top	Crushed Granite Chestertown	(WP)-Moderate	Good	Chestertown-Wevertown Asphalt Concrete Overlay on Pcc Pvt.
28 1710 1072	2	1A Top	Crushed Gravel Peckham, Chestertown	(WP) - Moderate/Severe (Shoulder)-Slight	Good	East of North D95541

Mile Post	Pavement Age, Yrs	Mix Type	Coarse Aggregate	Stripping Asphalt/Aggregate	Pavement Condition	Remarks
28 1710 1026	4	1A Top	Crushed Gravel Peckham, Chestertown	(WP) - Slight	Good	North Creek - Minerva RCR 74-13
28 2209 1488	10 est.	1A Top	Crushed Iron Ore Mine Tailings Barton Mines?	(WP) - None	Excellent	North Creek - Indian Lake
28 2209 1472	10 est.	1A Top	Crushed Iron Ore Mine Tailings Barton Mines?	(WP) - None	Excellent	North Creek - Indian Lake
28 2209 1027	3	1A Top	Crushed Gravel Peckham, Chestertown	(WP) - Slight	Good	Indian Lake - Blue Mt. Lake FARC 75-4
28 2209 1313	3	1A Top	Crushed Gravel Peckham, Chestertown	(WP) - Moderate/Severe	Good	Low Point in Vertical Grades
28 2209 1311	3	1A Top	Crushed Gravel Peckham, Chestertown	(WP) - Slight	Good	
28 2209 1239	2	1A Top	Limestone,Booneville Gravel, Poland	(WP) - Slight/Moderate	Good	Blue Mt. Lake - Raquette Lake Stripping concerns gravel and natural sand particles

Mile Post	Pavement Age, Yrs	Mix Type	Coarse Aggregate	Stripping Asphalt/Aggregate	Pavement Condition	Remarks
28 2209 1176	2	1A Top	Limestone,Booneville Gravel, Poland	(WP) - Moderate/Severe	Good	Blue Mt. Lake - Raquette Lake Larger % of gravel in mixture than in MP 1239
30 2206 1763	8 est.	1A Top	Crushed Gravel Whitney Estate	Varied from slight to severe in top course - severe in Open Binder	Poor/Fair	Long Lake - Tupper Lake Asphalt overlay on Pcc pavement with open binder. Pavement has many potholes.
30 7209 1001	7 est.	1A Top	Crushed Gravel Martin Pit, So. Colton	(WP) - Severe	Good	Long Lake - Tupper Lake
3 7205 1102	7 est.	1A Top	Limestone/Gravel Source Unknown	(WP) - Severe (gravel) - None (limestone)	Fair/Good	Tupper Lake - Saranac Lake
30 7209 1141	5 est.	1A Top	Crushed Granite Saranac Lake	(WP) - Moderate	Good	Tupper Lake - Malone
73 1201 1642	4	Open Graded Surface Course	Crushed Granite Saranac Lake	(WP) - Slight/Moderate	Good	Lake Placid - Keene Pavement has some fat spots

Mile Post	Pavement Age, Yrs	Mix Type	Coarse Aggregate	Stripping Asphalt/Aggregate	Pavement Condition	Remarks
Route 73 D95671	1	Dense Binder	Crushed Gravel Lewis	(WP) - Moderate	Fair/Good	Lake Placid - Keene Dense binder wintered over. Kling Beta Additive
73 1201 1600	10 est.	1A Top	Limestone Source unknown	(WP) - None	Good	Lake Placid-Keene
Route 73 D95671	12 est.	1A Top	Crushed Gravel Source unknown	(WP) - Top 3/4 inches-Slight Lower-Severe	Poor/Fair	Lake Placid-Keene Being resurfaced.